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LOCAL VERSUS PRODUCER CURRENCY PRICING: EVIDENCE FROM DISAGGREGATED DATA*

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The pricing behavior of firms is a central issue in international macroeconomics. Using the introduction of the euro as a natural experiment I find that year-to-year volatility in import prices among Eurozone members diminished by 4% on average after the introduction of the euro. Additionally, I show that the magnitude of the drop was commensurate with the drop in exchange rate volatility. On the other hand, when looking at exports, I find that the introduction of the euro had no impact on export price volatility. The results support the hypothesis of producer currency pricing.

1. INTRODUCTION

The pricing behavior of firms is a key issue in international macroeconomics, and it has important implications for a range of policy issues. For example, whether a devaluation succeeds in increasing demand for a country's goods depends on whether the prices are rigid in the currency of the producer or if the prices are rigid in the currency of the consumer. In the former case a devaluation increases the demand, but in the latter case it fails to do so. Appropriate monetary policy and optimality of the exchange rate regime thus depend on the pricing behavior of firms.[2]

In this article I study the pricing behavior of firms by investigating how import and export prices in Europe responded to exchange rate fluctuations in the periods before and after the introduction of the euro. My main hypothesis is that if prices are rigid in the (local) currency of the consumer, changes in the volatility of the nominal exchange rate should have no effect on the volatility of import prices. Therefore, although introduction of the euro eliminated nominal exchange rate volatility, there should have been no change in the volatility of import prices. In contrast, if prices are rigid in the currency of the producer, import prices respond to changes in the exchange rates, and adoption of the euro should have diminished import price volatility.

Using highly disaggregated trade data I find that import price volatility among Eurozone members diminished after the introduction of the Euro. On average, year-to-year changes in prices of Eurozone imports from other Eurozone exporters fell by 4% after the adoption of the common currency. I also show that the magnitude of the import price drop correlated with the magnitude of the drop in exchange rate volatility. In addition, I find that the introduction of the euro had no impact on average export price volatility. These results suggest the presence of producer currency pricing (PCP). Furthermore, I find stronger evidence of pricing in the currency of the producer for differentiated goods and for goods with lower elasticities of substitution, but not for commodities.

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[2] For a theoretical treatment of optimal monetary policy and exchange rate regime under local and PCP, see Obstfeld (2000), Devereux (2000), Devereux and Engel (2000, 2003), and Corsetti and Pesenti (2001, 2005).

I am able to use the introduction of the euro as a natural experiment because the decision whether or not to adopt the euro was not based on the pricing behavior of the firms. Many commentators, including Feldstein (1993, 1997), argue that the decision to enter the Eurozone was a political and not an economic one. Even if the decision was based on economic justifications, we have no reason to believe that the invoicing choice of the firms was important for the decision makers. Take, for instance, the case of the United Kingdom, where in 1997 Gordon Brown, the chancellor of the exchequer, suggested five tests that the British economy had to pass in order to enter the Eurozone, none of which related to the pricing behavior of British firms.[3] Finally, if we do assume that the choice to enter was based on the invoicing choice of firms—and we have no reason to believe that this is the case—then countries with producers pricing predominantly in their own currency would choose not to replace their local currencies with the euro. This is because the cost of giving up the local currencies as automatic stabilizers would be too high. Therefore, the sample of Eurozone countries would be biased toward countries with firms pricing in the currency of the consumer. Accounting for such selection bias, if it existed, is not a major concern since the bias works against the finding in this article that European firms predominately price in the currency of the producer.

Data on the invoicing choice of the firms are hard to come by.[4] In the absence of such data, several studies attributed deviations from the Law of One Price (LOP) and incomplete exchange rate pass-through to local-currency pricing. Engel (2000) found that the LOP failed in a sample of 22 goods categories from nine European countries. He concluded that the results support the presence of pricing in the currency of the consumer (LCP). Looking at five aggregate import bundles, namely, food, manufacturing, energy, raw materials, and nonmanufacturing, Campa and Goldberg (2005) found that there is partial exchange rate pass-through to import prices in the short run and so rejected both hypothesis that prices are set in the currency of the producer (PCP) or the consumer (LCP). Using more disaggregated data, Goldberg and Verboven (2005) examined auto prices in five European countries from 1970 to 2000 and found strong convergence toward both the absolute and the relative versions of the LOP. They also found high degrees of pass-through, suggesting that pricing in the currency of the producer is a common practice for automakers selling in Europe.

The literature described above made important contributions to our understanding of LOP and exchange rate pass-through. Yet, extending the findings to make inferences about the pricing behavior of firms requires caution, as there is not one-to-one mapping between the pricing behavior of firms and deviations from LOP and incomplete pass-through. Deviations from the LOP can occur both when pricing in the currency of the producer or the consumer takes place, as long as there is price discrimination (Giovannini, 1988). Similarly, incomplete exchange rate pass-through can be mainly attributed to other factors, such as nontraded costs (Goldberg and Hellerstein, 2008) and product replacement bias (Nakamura and Steinsson, 2010).

An advantage of the methodological framework presented here is that I can link changes in price volatility directly to firms' pricing behavior. And because I work in a cross-sectional framework where each regression has about 40,000 observations, small-sample bias is not a serious concern. Aggregation bias is also reduced by using disaggregated unit price data on traded goods.[5]

[3] Gordon Brown's five tests were (1) whether there can be sustainable convergence between Britain and the economies of the single currency, (2) whether there is sufficient flexibility to cope with economic change, (3) the effect on investment, (3) the impact on the financial services industry, and (5) whether it is good for employment (Krugman and Obstfeld, 2008, p. 581).

[4] A very nice study by Gopinath et al. (2010) does not face the data limitation. The authors have access to a novel data set on currency and prices of U.S. imports. They find that around 90% of U.S. imports are priced in dollars, although this fraction varies by country of origin.

[5] Imbs et al. (2002, 2005), Crucini and Shintani (2008), Chen and Engel (2004), and Broda and Weinstein (2008) are some of the studies that discuss the importance of the different biases. Crucini and Shintani and Chen and Engel show the importance of measurement error bias and small-sample bias. Imbs et al. show that aggregating data introduces an important bias because the components of an index have heterogeneous dynamics. They advise against using aggregated

Another important advantage of using the Difference-in-Difference methodology is that having data on markups and marginal costs is not required for making inferences. This is because any changes in markups and marginal costs are captured by the fixed-effect coefficients and do not affect the coefficient of interest. Note also that markups or marginal costs need not be identical across trading partners, and they need not be affected uniformly by the introduction of the euro. Any shift in markups and marginal costs that might be attributed to the introduction of the euro will be time-invariant and will be swept out by the differencing of prices at the product–reporter–partner level in the years after 2001.

The article is organized as follows. Section 2 establishes the methodology used for exploring price sensitivity before and after the euro. Section 3 describes in detail the data set used. Section 4 presents the results, and Section 5 summarizes the findings and concludes this work.

2. METHODOLOGY

I develop a framework that enables me to examine the sensitivity of prices to exchange rate movements using cross-sectional data from the periods just before and after the introduction of the euro. The idea is the following: if prices are rigid in the producer's currency and exchange rates fluctuate, then import prices will be volatile, but not export prices. When introduction of the euro eliminates exchange rate volatility, import price volatility should diminish, but export price volatility should not change. Alternatively, if prices are rigid in the consumer's currency and the exchange rate fluctuates, import prices will not be volatile but export prices will be. When the exchange rate volatility disappears, one should observe a drop in export price volatility but no change in import price volatility. By looking at how import or export price volatility changes after the introduction of the euro, one can infer whether prices are set in the currency of the producer or the consumer. That is, to test whether PCP or LCP occurs, it suffices to check for changes in price volatility under the floating (pre-euro) and the fixed (post-euro) regimes. Notice that this test can be performed with export or import prices. I will be able to check robustness of the results by doing both tests.

To measure price volatility I use the five-year period from 1994 to 1998 as the BEFORE period and the five-year period from 2002 to 2006 as the AFTER period. Since several other factors other than fluctuations in the exchange rate, such as changes in markups and marginal costs, may also affect price volatility, I use the set of all OECD countries to construct a control group and a treatment group. The control group (the non-EZ group) is the set of OECD countries outside the Eurozone, and the treatment group (the EZ group) is the set of all OECD countries in the Eurozone.[6] I focus on OECD countries to reduce heteroskedasticity. That might arise by comparing developed countries with developing ones. The sample covers a high percentage of all trade by the EZ and non-EZ OECD countries.[7]

To see what happens to the volatility of prices before and after the euro, a Differences-in-Differences (DID) regression framework is employed.[8] In the DID framework, any change in price volatility not captured by the time dummy or the group dummy is the result of the introduction of the euro. For imports of Eurozone members the regression is

$$(1) \quad \overline{\left|(\ln P_{cgit} - \ln P_{cgit-1})\right|} = a_0 + \alpha_1 AFTER_t + \sum_{\mathbf{c}} \sum_{i} \beta_{ci} \mathbf{D}_{ci} + \alpha_3 EZ_i * AFTER_t + u_{cgit},$$

data so that these dynamics are not averaged out and do not produce misleading results. Finally, Broda and Weinstein find that vast amount of information on market fragmentation across space is lost when one uses price indexes. They find strong nonlinear responses at the disaggregated level, and, therefore, they also advise against using aggregated data.

[6] The two groups are OECD-EZ (Austria, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, and Spain) and OECD non-EZ (Australia, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States). Turkey and Mexico are dropped from the non-EMU group since both countries experienced high inflation for part of the period under consideration.

[7] We find on average that 70% of an OECD country's trade is with other OECD countries.

[8] See Woodridge (2010, pp. 150–151).

TABLE 1
THEORY PREDICTIONS FOR THE SIGN OF $\alpha 3$

	PCP	LCP
Imports	<0	0
Exports	0	<0

NOTES: The table summarizes predictions under PCP and LCP for EMU import and export price volatility after the introduction of the euro (sign of $\alpha 3$).

where c denotes a reporting country (an importer) from among the EZ group. The set of trade partners (exporting countries) is indexed by i and it includes all OECD members. $\mathbf{D}_{ci}$ is a dummy variable that captures reporter–partner (importer–exporter) fixed effects, g denotes the product (a six-digit harmonized system [HS] code), and t denotes the time ($t = 1995, 2003$). The dependent variable $\overline{(\ln P_{cgit} - \ln P_{cgit-1})}$ is the five-year average of the absolute annual changes in the unit value of a specific HS6 category between two trading partners in each period. $AFTER_t$ is a dummy variable that takes the value 1 if the year is 2003 to 2006 and 0 otherwise. It captures aggregate factors that affect unit value volatility over time in the same way for both groups. Finally, $EZ_i * AFTER_t$ is a dummy that takes the value of 1 if the observation corresponds to an import from an EZ-group country (origin) after the introduction of the euro.

The coefficient of interest is α_3, which is usually called the DID coefficient. I also estimate Equation (1) using export data. In this case, the subscripts are the same, except that the reporting country, c, is the exporter and the trade partner, i, is the importer. By defining the dependent variable as $\overline{|(\ln P_{cgit} - \ln P_{cgit-1})|}$ I can directly interpret α_3 as the percentage change in import or export price volatility that is caused by the introduction of the euro. Following Broda and Weinstein (2006), I define a product to be an HS6 code. For example, "wild blueberries canned" is a product. I define a variety to be a product per destination per origin. For example, "Italian wild blueberries canned exported to France" is a different variety than "Italian wild blueberries canned exported to Germany." I restrict the sample to contain varieties that exist for all years between years 1994 and 2003 in order to eliminate the risk of spurious results driven by changes in the composition baskets of imported and exported goods at the bilateral level. For a robustness check, product dummies were included in the regressions, but the results did not change. Finally, notice that country and variety fixed effects are included in the regressions, the former by including country dummies and the latter by taking annual differences of varieties' prices.

The sign of α_3 reveals if prices are set more according to PCP or LCP. When the dependent variable is calculated from import prices, $\alpha_3 < 0$ means that import price volatility from EZ members dropped after the introduction of the euro. This is only consistent with the PCP hypothesis. If $\alpha_3 = 0$, then there was no change in import price volatility after the introduction of the euro, which is consistent with LCP. By looking at the sign of α_3 I can therefore determine whether PCP or LCP occurs.

When the dependent variable is calculated using export data, the predictions are reversed. A $\alpha_3 < 0$ implies that export price volatility from other EZ members dropped after the introduction of the euro. This can only be consistent with LCP. If $\alpha_3 = 0$, then there is no change in export price volatility, which is consistent with PCP. Finally, notice that, in principle, α_3 should not be positive, because we cannot think of a scenario under which a drop in nominal exchange rate volatility raises import price volatility. The relation between the sign of α_3 and the two contrasting pricing theories is summarized in Table 1.

Observations are clustered at the trade-partner level by period. I do this to account for the fact that the error terms may be heteroskedastic and correlated within these subsets of observations.[9]

[9] Although it would be natural to cluster by product classifications within trade-partner pairs by time period, I lack sufficient data to make this work.

The results I will discuss below based on the regression framework above are not driven by changes in pass-through.[10] Pass-through most often changes as a result of changes in inflation or changes in the composition of the baskets of traded goods caused by shifts in the weights of the trading partners. But in Europe, inflation rates came down in the early '90s and stayed stable ever since.[11] Furthermore, one may worry about changes in the composition of the baskets of traded goods. This is a legitimate concern if one expects that after the introduction of the euro the Eurozone countries traded more with each other and less with non-Eurozone partners, causing a shift in the composition of traded goods, and perhaps a change in pass-through. However, the potential effects are controlled for by the DID methodology, where for each country I examine two baskets of traded goods, one with Eurozone partners and one with non-Eurozone partners. Moreover, even within each basket of traded goods, I do not allow entry and exit of varieties. Finally, the concern that changes in pass-through may affect the results diminishes since a study by Goldberg et al. (2007) finds no structural breakdown in pass-through as a result of introducing the euro.

Finally, note that any changes in markups, marginal costs, or inflation rates lower import prices to both EZ and non-EZ destinations, and, consequently, they do not affect α_3. Not having to worry about marginal costs and markups is an advantage of the DID framework presented in this study, since having to measure the two variables presents a major challenge.

3. DATA DESCRIPTION

I use six-digit imports and exports data from the HS for the period from 1994 to 2004 to obtain unit prices. The data come from the United Nations Commodity Trade Statistics Database, which is commonly known as COMTRADE. I use data from 1994 to 1998 and 2002 to 2003 for the regressions. All value data are converted from U.S. dollars to local currencies using the conversion rates reported by COMTRADE. Unit values of each variety are used as proxies for actual prices. "Unit values" and "prices" are used interchangeably.

Before proceeding with formal tests, let me point out the following stylized fact: The price volatility of a traded variety appears to be inversely related to its trade volume. Figure 1 depicts this relation. On the *x*-axis, exports are allocated in bins based on log trade volume. The *y*-axis is the mean price volatility for all varieties within the same trade volume bin. The data are pooled together across time and among partners. The graph shows that low export trade values are associated with higher price volatility on average. As the value of traded goods increases, price volatility decreases. This pattern is persistent across time and exporter group: Identical distributions were obtained for EZ and non-EZ and for the BEFORE and AFTER periods.[12]

A possible explanation of the high price volatility observed at low trade volumes is measurement error. Consider "wild blueberries canned." It is hard to imagine the quality of "wild blueberries canned" exported to Italy changing from year to year. Therefore, on average, one would expect the price to be constant. Now, consider a different product: "Industrial Robots for Lifting, Hand, Load, or Unload." The U.S. exported two units to New Zealand in 1996 at a price of USD 44,338 per unit and five units in 1997 at a price of USD 6,180. The description of the HS code for this product indicates that these robots are customized for the specific needs of a plant, so even at this high level of disaggregation, we have highly differentiated products sharing the same HS code. Broda and Weinstein (2006) discuss such measurement errors in their work. They propose a weighting scheme based on expenditure shares that reduces measurement error

[10] Several recent studies argue that pass-through rates have declined over time. See Taylor (2000), Frankel et al. (2005), and Campa and Goldberg (2008).

[11] See Krugman and Obstfeld (2008, figure 20.2, p. 570).

[12] The results are available at www.georgetown.edu/faculty/aa658/research.html

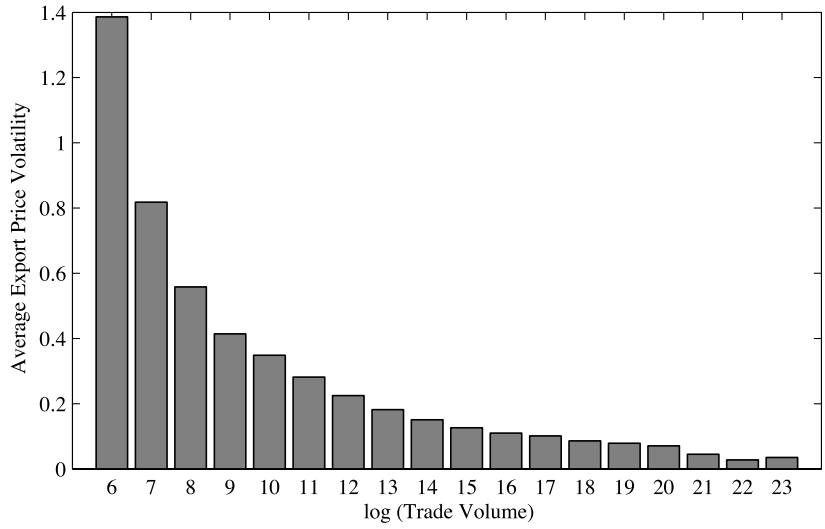

FIGURE 1

EXPORT PRICE VOLATILITY AND TRADE VOLUME

related to the use of unit prices. Following their advice I value-weight the data. I also clean the data to reduce noise.[13]

Nevertheless, one may still criticize the accuracy of unit-value data. To the extent that errors in the data are nonsystematic and do not bias my results in a certain direction, the results in this article will be robust. COMTRADE data have been used in several studies in the past.[14] An advantage of the regression framework proposed here is that the DID approach will wipe out any effects that these data inaccuracies have on a_3, the coefficient of interest, as such effects will be captured by the period and group fixed effects.

4. RESULTS

4.1. *Pooled Regressions.* Regression (1), estimated using imports data for all EZ countries, produces the estimates shown in Column 1 of Table 2. The coefficient of $EZ_i * AFTER_t$, $(\widehat{\alpha}_3)$, shown in bold, is negative and statistically significant. The negative coefficient provides evidence of PCP, and a 4% reduction in import price volatility of EZ imports from other EZ members can be attributed to the introduction of the euro.

When specification (1) is estimated using all EZ exports to both OECD-EZ and OECD-non-EZ destinations, results are as shown in Column 2. The coefficient of interest, $\widehat{\alpha}_3$, is now 0.004. EZ export prices to other EZ members did not become less volatile as a result of the introduction of the euro. This also supports the presence of PCP.

Summarizing, I find that the introduction of the euro brought about a 4% drop in year-to-year change in prices of EZ imports from other EZ members. However, it had no effect on export price volatility. This is consistent with firms setting prices in the currency of the producer (PCP).

[13] Varieties with fewer than 100 units traded in a given period and varieties that experienced extraordinary change in quantity from one year to the next are eliminated. Any change in absolute log quantity greater than 1 is considered to be an extraordinary (i.e., 170% change).

[14] For example, see Tybout (2000), Chang and Winters (2002), Broda and Weinstein (2006), Revenga (1992), Fisman and Wei (2004), and Anderson and van Wincoop (2004).

TABLE 2
POOLED REGRESSION

	IMPORTS (3)	EXPORTS (4)
AFTER	0.0247***	−0.0220
	(3.79)	(−1.41)
$EZ_i AFTER_t$	**−0.036*** **	**0.004*** **
	(−2.38)	(3.78)
Constant	0.197***	0.239***
	(5.48)	(13.27)
Observations	399,452	424,507
R-squared	0.61	0.64

NOTES: Reporter–Partner Interactions are omitted from the table. Observations are clustered at the trade-partner level by period. *t*-statistics are in parentheses. ***$p < 0.01$.

4.2. *Country-Specific Regressions.* One may worry that the results above are driven by just one country. To check this, I repeat the exercise for each EZ country. That is, specification (1) is estimated again, but this time c is restricted to just one value each time. Each value corresponds to a different EZ country. Table 3 presents the results. Each column presents a different regression.

The results in the country-specific regressions further support PCP and show that the reduction in import price volatility observed in the pooled regression is not driven by just one country. In all but two EZ countries, I find strong evidence that import price volatility from other EZ countries dropped after the introduction of the euro. For example, the DID coefficient estimate $\widehat{\alpha}_3$ $(EZ_i * AFTER_t)$ obtained from the regression using Austrian imports prices implies that there is a 2.3% reduction in the volatility of import prices from other EZ members that is attributed purely to the policy change (i.e., the introduction of the euro). The drop in import price volatility varies from as low as 2% for Netherlands to as high as 10% for Spain. Overall, the results provide strong support for the presence of PCP. A possible explanation for the range of volatility reductions across countries is that EZ countries had various degrees of exchange rate fluctuations before adopting the euro. Thus, I explore this hypothesis in detail later on and find that, indeed, the magnitude of the drop is directly related to the level of the exchange rate fluctuation before the introduction of the euro.

Germany is one of the two countries for which a decline in import price volatility is not observed (the other country is Portugal). This suggests that when exporting to Germany prior to the euro, firms tended to choose LCP over PCP. The fact that the Deutsch mark was a stable currency, that the currency was the precursor of the euro, and that it tended to appreciate versus the other currencies in the mid-'90s may explain why a bigger share of firms exporting to Germany were choosing to price in Deutsche marks than in their own currencies.

Table 4 presents the results of country regressions on export data. For all countries, except Portugal, there is a small decline in export price volatility: about 2% or less. This implies that some pricing in the currency of the consumer (LCP) occurs. However, since the magnitude of the decline in import price volatility is much larger than the decline in export price volatility (4% versus 0.5% on average), it appears that PCP pricing dominates LCP pricing in Europe.

Again, Germany is an exception to the rule: Germany's export price volatility did not decline after the introduction of the euro. The interpretation of this finding is that prior to the euro, most German exporters chose to price in Deutsche marks. As discussed above, given the stability of the Deutsche mark, we should expect this to be the case.

The evidence from the country-specific regressions is consistent with the idea that price setting in the currency of the producer is widespread among firms in the EZ economies. Including product dummies in the regressions changes the coefficients slightly but not the qualitative results. Since the introduction of the euro eliminated nominal exchange rate fluctuations between

TABLE 3
COUNTRY-SPECIFIC REGRESSIONS: IMPORTS

	Austria	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain
AFTER	0.091***	0.006	0.049	0.024**	0.147**	0.062***	0.053***	0.050**	0.017	0.065***
	(−8.20)	(−0.33)	(−1.40)	(−2.66)	(−2.57)	(−4.24)	(−5.89)	(−2.64)	(−1.57)	(−3.41)
$\mathbf{EZ_i AFTER_t}$	**−0.023***	**−0.062****	**−0.054****	**0.030***	**−0.085*****	**−0.033**	**−0.082*****	**−0.016**	**0.025**	**−0.101*****
	(−1.99)	(−2.54)	(−2.52)	(−1.95)	(−3.32)	(−0.49)	(−8.54)	(−0.60)	(−0.76)	(−2.94)
Constant	0.075***	0.174***	0.105***	0.118***	0.152***	0.247***	0.086***	0.162***	0.129***	0.131***
	(28.7)	(21.0)	(8.16)	(16.4)	(5.21)	(18.0)	(28.1)	(12.8)	(4.97)	(5.07)
Observations	34,962	33,198	55,012	56,929	23,573	19,449	49,395	67,214	30,366	42,161
R-squared	0.183	0.301	0.373	0.2	0.268	0.16	0.318	0.312	0.213	0.235

NOTES: Each column represents a different regression. Partnerd dummies are omitted from the table. Observations are clustered at the trade-partner level by period. *t*-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

TABLE 4
COUNTRY-SPECIFIC REGRESSIONS: EXPORTS

	Austria	Finland	France	Germany	Greece	Ireland	Italy	Netherlands	Portugal	Spain
AFTER	0.079	0.089***	0.006	−0.025*	−0.014	−0.081	0.006	0.086***	0.060***	0.057***
	(0.51)	(3.82)	(0.46)	(−2.00)	(−0.72)	(−1.31)	(0.56)	(9.06)	(10.4)	(2.89)
EZ_iAFTER$_t$	**0.049**	**−0.011**	**−0.001**	**0.070*****	**−0.019***	**0.090**	**−0.014**	**−0.013****	**−0.125*****	**0.026**
	(0.32)	(−1.30)	(−0.97)	(5.24)	(−1.69)	(1.12)	(−1.20)	(−2.71)	(−7.56)	(0.86)
Constant	0.212***	0.157***	0.115***	0.078***	0.227***	0.326***	0.108***	0.134***	0.153***	0.061***
	(4.94)	(16.3)	(9.77)	(9.92)	(18.6)	(6.53)	(26.8)	(21.5)	(14.2)	(3.55)
Observations	26,946	15,502	72,522	84,094	4,756	6,895	75,016	88,223	11,377	39,176
R-squared	0.437	0.195	0.06	0.232	0.234	0.176	0.069	0.107	0.021	0.367

NOTES: Each column represents a different regression. Partner dummies are omitted from the table. Observations are clustered at the trade-partner level by period. *t*-statistics are in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

EZ members, and I did find that EZ import price volatility from other EZ members declined, I conclude that pricing in the currency of the producer dominates pricing in the currency of the consumer.

Although the statement above refers to the conditional effect of the euro in import and export prices, it is worth pointing out that the unconditional effect of the euro is to increase the volatility of import prices. This is shown by the positive and statistically significant coefficients of the AFTER variable in most of the regressions using imports data. In contrast, the unconditional effect of the euro on export price volatility has been limited. This is explained by the fact that the exchange rate volatility has risen in the period AFTER.[15] If firms set prices in the currency of the producer, as this article finds, then we should expect to see the unconditional import price volatility rise as the exchange rates become more volatile. At the same time, we should not expect the unconditional export price volatility to change much with prices set in the currency of the producer.

4.3. *Import Price Volatility and Exchange Rate Fluctuations.* I interpreted the decline in import prices volatility as evidence in favor of PCP. In this section I consider whether cross-country variations in the pre-euro nominal exchange rate volatility explain variations in the magnitude of import price volatility declines. The hypothesis is that the effect of the euro on reducing price volatility would be greater for countries that had volatile exchange rates in the past. For countries with stable exchange rates, the euro should have less of an impact.

To investigate this I plot the decline in import price volatility between 1994/1995 and 2002/2003 against the absolute change in the trade-weighted exchange rate between 1994 and 1995. Here I do not use a five-year window for the periods before and after in order to link annual changes in import price volatility for a country with the change in its trade-weighted exchange rate before the introduction of the euro. The time aggregation over the five-year windows would make it impossible to make the linkages. The weights are based on each country's imports from the other EZ countries. The result is presented in Figure 2. The plot shows a positive correlation between a country's exchange rate fluctuation before the euro and the magnitude of the decline in import price volatility after the introduction of the euro. France and Spain seem to have experienced a much larger drop in import price volatility than most countries.

I can also capture the positive relationship between the decline in import price volatility and the pre-euro exchange rate volatility by regressing the $\widehat{\alpha}_3$ coefficient on the (abs) log change of

[15] A simple exercise using a trade-weighted exchange rate for the euro area in the years before and after the introduction of the euro shows that exchange rate volatility has risen by about 50%.

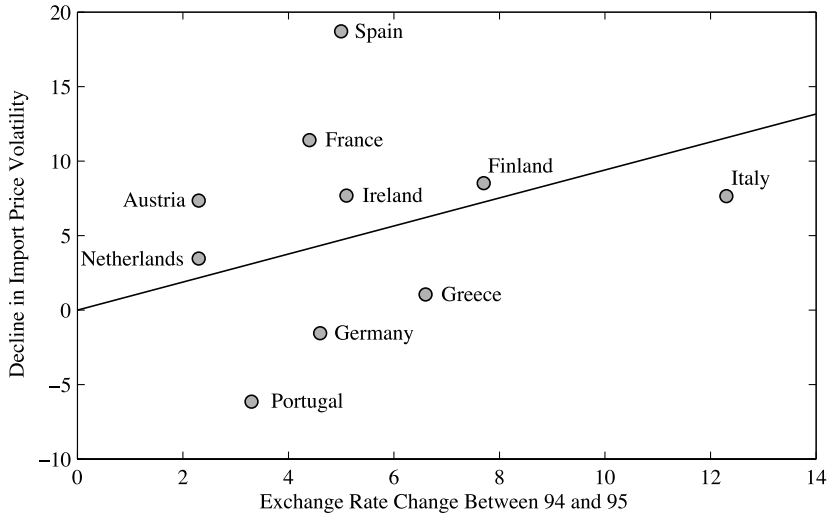

FIGURE 2

DECLINE IN IMPORT PRICE VOLATILITY VERSUS EXCHANGE RATE FLUCTUATIONS

the exchange rate between 1994 and 1995. The estimated equation is

$$\widehat{a}_3 = \underset{(-2.56)}{0.94\Delta s_t}, \quad R^2 = 0.42 \tag{2}$$

with the *t*-statistic in parentheses. The coefficient in this regression shows that for the countries that experienced a drop in import price volatility, the magnitude of the drop is proportional to the drop in exchange rate volatility as predicted by the LOP.

4.4. *Product Differentiation and Invoicing Choice.* The Difference-in-Difference approach developed in this article can address one additional and important empirical question. Recent evidence suggests that market structure is a determinant of the pricing choice.[16] The degree of good heterogeneity determines whether a firm chooses to price in local (LCP) or producer (PCP) currency (or to price in USD even if the trade does not involve the United States). By allocating goods into three broad categories as suggested by Rauch (1999), Goldberg and Tille (2006), Colacelli (2010), and Gopinath et al. (2010) find a higher percentage of nondollar pricing in differentiated goods sectors than in reference-priced or commodity sectors.[17] These studies find that the degree of pass-through is related to pricing choice and is the highest in the differentiated goods sectors.

This evidence poses the following testable hypothesis: Focusing on imports among EZ members, the import price volatility decline after introduction of the euro should be larger for differentiated goods than for reference priced goods or commodities. If pricing in dollars is more common for commodities, then the introduction of the euro should not have a large impact on import price volatility. By contrast, if nondollar pricing is more common for differentiated goods, then import price volatility between EZ members should fall after the introduction of the euro.

[16] Simple models of market structure and pricing choice can be found in Dornbush (1987), Krugman (1987), Marston (1990), Goldberg and Tille (2006), and Hodrick and Bekaert (2008).

[17] According to Rauch (1999), "Organized Exchange" traded goods cover products that have an overt market (i.e., precious metals). "Reference Price" goods are homogeneous goods that do not have a substantial enough volume to have an "official" market (e.g., obscure chemical products), but are homogeneous enough to have "reference" prices that are published in trade magazines.

TABLE 5
CHANGE IN IMPORT PRICE VOLATILITY BY RAUCH CLASSIFICATION

	Rauch's Classification of Goods		
	Commodity	Reference Priced	Differentiated
EMUi_AFTER	0.028	−0.039***	−0.067***
	(1.55)	(−2.61)	(−2.37)
Observations	124,399	250,479	327,110
R-squared	0.72	0.697	0.672

NOTES: I classify all imported goods into Commodity, Reference Priced, and Differentiated following the Rauch (1999) classification system. I then estimate the pooled regression for each category and report the DIDs coefficient. Observations are clustered at the trade-partner level by period. *t*-statistics are in parentheses. ***p < 0.01.

To test this hypothesis I allocate all EZ imports data into the following three groups: commodity, reference priced goods, and differentiated goods. The groups are based on Rauch's classification system at the four-digit SITC code. Rauch provides a "conservative" and a "liberal" classification. The results shown are based on the liberal classification. Using the conservative classification yielded identical results and was therefore omitted. To check the effect of the euro on import price volatility for each group, I pool all EZ imports together and estimate Equation (1) for each product group.

Table 5 reports the estimate for the DIDs coefficient ($\widehat{\alpha}_3$) from the three regressions with *t*-statistics in parentheses. For each regression I report the coefficient of $EZ_i * AFTER_t$, the R^2, and the number of observations. Among EZ members, import price volatility in differentiated goods from other EZ destinations dropped by 6.2% after the introduction of the euro. By contrast, there was no decline in import price volatility for commodity goods (there is a 3% drop in the case of reference-priced goods). The strong evidence of PCP for heterogeneous goods but no evidence for commodities match the findings of Goldberg and Tille (2006), Colacelli (2010), and Gopinath et al. (2010), and provide a robustness check to the methodology suggested in this article.

An alternative way to examine how market structure affects pricing choice of firms is to allocate all varieties into bins based on their elasticities of substitution. Elasticity data are taken from Broda and Weinstein (2006). The hypothesis is that as the elasticity of substitution increases, more firms will choose LCP over PCP, because high elasticity of substitution indicates high competition. Therefore, firms will tend to set prices in the currency of the consumer in order to avoid substantial demand reductions when exchange rates move against them. Regression (1) is now estimated for each of the three elasticity bins. The results are given in Table 6. For products with high elasticities, there is no drop in import price volatility. However, for products with low elasticities of substitution, the drop in import price volatility is substantial. There is a

TABLE 6
CHANGE IN IMPORT PRICE VOLATILITY BY PRODUCT ELASTICITY

	Elasticity of Substitution (σ)		
	5+	3–5	1–3
EMUi_AFTER	−0.004	−0.004	0.095**
	(−0.28)	(−0.17)	(−3.15)
R-squared	0.60	0.45	0.37
Observations	35,907	83,512	279,191

NOTES: I allocate all imported goods into three bins based on the elasticity of substitution of the particular good. The elasticity data come from Broda and Weinstein. I then estimate the pooled regression for each category and report the DIDs coefficient. Observations are clustered at the trade-partner level by period. *t*-statistics are in parentheses. **p < 0.05.

10% drop in the volatility of inelastic EZ imports from other EZ members as a result of the euro. The results are not surprising since most commodities fall in the high elasticity bin ($\sigma > 5$) and most of the differentiated products fall in the low elasticity bin ($1 < \sigma < 3$).

5. CONCLUSION

In this article I used the introduction of the euro as a natural experiment to see how prices are set. By examining import and export price volatility before and after the introduction of the euro, I found that for the EZ countries, import price volatility from other EZ members diminished as the result of the euro, whereas export price volatility did not change. Furthermore, I showed that the magnitude of the drop in import price volatility was proportional to the pre-euro volatility in the nominal exchange rate. I also showed that pricing in the currency of the producer is more common for differentiated products and products with lower elasticities of substitution.

These findings support the presence of PCP. For the EZ countries, adopting the euro came at a high economic cost because the countries gave up the ability to have their local currencies act as automatic stabilizers to economic shocks. This concern, which was first expressed by Feldstein (1993, 1997) and Obstfeld (1997), and relied on prices set in the currency of the producer, seems to be valid based on the evidence in this study.

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